

## Claims

- [c1] An in-line swivel comprising:
  - a tubular retainer sub;
  - a swivel mandrel having an enlarged rounded head at its upper end; and
  - a retainer nut providing an opening larger than an outer diameter of a lower end of the tubular swivel mandrel, connected to the tubular retainer sub enclosing said rounded head of the tubular swivel mandrel to permit deflection of the swivel mandrel and enclosing a bearing having an upper surface conforming to the rounded head of the tubular swivel mandrel to thereby permit rotational movement of the mandrel upon deflection of the swivel mandrel from the longitudinal axis of the retainer sub.
- [c2] The drill rig swivel apparatus of claim 1 further comprising a socket bushing inserted in the interior surface of the retainer sub providing a profile conforming to the rounded head of the tubular swivel mandrel.
- [c3] The drill rig swivel apparatus of claim 1 further comprising a backup ring retained between an upper edge of the bearing and a lower hemispherical surface of the swivel

mandrel to permit deflection of the swivel mandrel.

- [c4] The drill rig swivel apparatus of claim 1 wherein the bearing is lubricated by injection of lubricant from a lower edge of retainer nut.
- [c5] The drill rig swivel apparatus of claim 1 further including one or more seals on an upper hemispherical surface of the swivel mandrel to prevent egress of drilling fluid around the mandrel into the bearing supporting the mandrel in the retainer sub.
- [c6] The drill rig swivel apparatus of claim 1 further including a hardened insert retained in a lower radial portion of the retainer sub providing a cooperating hemispherical surface conforming to the rounded upper surface shape of the swivel mandrel.
- [c7] The hardened insert of claim 6 further comprising seals to prevent drilling fluid from flowing around the insert to reach the bearing.
- [c8] A deflection swivel to allow the deflection of a tubular string attached thereto, the deflection swivel comprising:
  - a retainer sub, said retainer defining a receptacle;
  - a socket bushing within said receptacle, said socket bushing having a substantially spherical bushing surface;

a swivel mandrel having a spherical distal end, said spherical distal end configured to be sealingly received into said spherical bushing surface;  
a bearing assembly, said bearing assembly configured to resist movement of said spherical distal end away from said socket bushing;  
a retainer nut, said retainer nut configured to compress said bearing assembly, said spherical distal end, and said socket bushing within said receptacle.

- [c9] The deflection swivel of claim 8 further comprising a backup ring located between said bearing assembly and said spherical distal end, said backup ring having a second spherical bushing surface to engage said spherical distal end opposite said socket bushing.
- [c10] The deflection swivel of claim 9 wherein said backup ring is constructed as part of said bearing assembly.
- [c11] The deflection swivel of claim 8 wherein said bearing assembly includes a thrust bearing.
- [c12] The deflection swivel of claim 8 wherein said bearing assembly includes a journal bearing.
- [c13] The deflection swivel of claim 8 wherein said retainer nut includes a hydraulic port, said hydraulic port configured to communicate with said bearing assembly.

- [c14] The deflection swivel of claim 8 wherein said socket bushing is integral to said retainer sub.
- [c15] The deflection swivel of claim 8 wherein the tubular string is a drill string.
- [c16] The deflection swivel of claim 8 wherein the tubular string is a pipeline string.
- [c17] The deflection swivel of claim 8 wherein said retainer nut limits axial deviation of said swivel mandrel with respect to said retainer sub.
- [c18] The deflection swivel of claim 8 further comprising a plurality of seals between said socket bushing and said receptacle.
- [c19] The deflection swivel of claim 8 wherein said retainer nut is threadably engaged upon said retainer sub.
- [c20] A method for coupling adjacent sections of a tubular string, the method comprising:
  - attaching a first end of a deflection swivel to a relatively rigid section of the tubular string;
  - coupling a relatively displaceable section of the tubular string to a second end of the deflection swivel;
  - articulating the displaceable section with respect to

**the rigid section through a ball and socket joint  
within the deflection swivel.**